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Abstract

Introduction: A randomized controlled trial was undertaken to compare the efficacy of three methods of delivering information on short- and long-term recall of information in orthodontic patients and parents. **Method:** Participants who received an audio-visual presentation on orthodontic treatment were randomly allocated to one of three written information groups (leaflets, generic or participant's customized mind map). A questionnaire was used to assess short- and long-term retention of information (maximum score 30). **Results:** Eighty-eight (94.6%) patients and seventy-seven (86.5%) parents completed the study. The average knowledge scores at baseline (95% CI) for the patient groups were 17.71 (16.28-19.14), 16.58 (14.67-18.49) and 17.37 (15.92-18.81) respectively. The parents knowledge scores for the three groups were 19.06 (17.51-20.62), 19.39 (17.44-21.35) and 18.76 (17.19-20.33) respectively. The short- and long-term knowledge scores significantly improved over baseline in all three groups ($p < 0.0001$). The parents achieved significantly higher scores than the patients ($p = 0.002$) and the rate of forgetting information was less. The knowledge scores of the mind map groups were significantly higher than that of the leaflet group for all cohorts ($p = 0.025$). No statistical difference was found between the type of mind map. The correlation between patient and parent knowledge scores was significant ($p < 0.0001$) at all three time points. **Conclusion:** Provision of an audio-visual presentation and one of three written information methods is an effective way of delivering information. There was a small but significant improvement in the retention of information using mind maps compared to leaflets. The generic mind map is equally as effective, more consistent in information delivered, and less labor-intensive than the individuals custom-made mind map, therefore would be our recommendation for use. Participation of parents is important as they comprehend and retain information better, in this study 100% of parents shared information with their children thereby improving the patients' recall. **Registration:** This trial was registered with the London Bridge Research Ethics Committee (Reference 17/LO/0422). **Protocol:** The protocol was not published before trial commencement. **Funding:** No financial support was required

Introduction

Good communication and effective delivery of information are key processes in health care provision.¹ Evidence suggests that a patients' overall satisfaction with care received is greatest when they believe adequate information has been provided.² Good communication also supports the patient to understand and retain more quality information that may lead to reduced anxiety, improved patient compliance and subsequently a better treatment outcome by altering behavior patterns.³⁻⁵ Spelman et al. (1967) stated that communication is deemed effective when the patient understands and retains information given.⁶ Many studies have reported that orthodontic patients and parents do not always comprehend and retain information given and poor short-term or long-term retention of orthodontic information may lead to patient complaints or even litigation.⁷⁻⁹ Sufficient information must be delivered in easy format to ensure patients understand and retain information given.¹⁰

McGuire (1996) reported that patients immediately forgot 60-80% of medical information presented and their recall got worse with increased amount of information.¹¹ Similar findings were noted in orthodontic studies. Witt and Bartsch (1993) assessed the retention of information by orthodontic patients during initial consultation and concluded that only 30% of information given was recalled correctly after 10 days.¹² In this study, patients were more likely to retain information that concerned or interested them and affected everyday life. Baird and Kiyak (2003) studied twenty-one orthodontic patients who had been in treatment for 1 to 24 months as well as one of their parents or guardians to assess their understanding of orthodontic treatment.⁷ The study concluded that both patients and parents had poor recall of diagnosis and risks associated with orthodontic treatment, and there was a positive correlation between parents' vocabulary or educational levels and the level of comprehension of the orthodontic information given. A similar study was conducted with twenty-nine orthodontic patients and their parents at the orthodontic case presentation appointment in the same University by Mortensen et al. (2003).⁸ The study concluded that

short-term recall of patients and parents was poor, especially of significant associated risks such as relapse, caries and periodontal problems.

Individuals differ in how they learn and tailoring instruction according to individuals' learning style may improve recall of information given.¹³ Some individuals may have strong preference to visual learning, whilst others may prefer to learn through kinesthetic modality.¹⁴ Verbal communication is a commonly used source of information, however often it is not effective as medical professionals use technical terminologies that are unfamiliar to the general public.¹⁵ Medical research suggested that patients only retain about 20% of verbal information given and this may increase by 50% when supplemental written and/or visual information is provided.¹⁶ A number of research papers also concluded that medical patients favored verbal instructions with supplemental written leaflets and retained more information resulting in better understanding and compliance.¹⁷⁻¹⁹ The readability of orthodontic leaflets is recommended to be aimed at eighth grade (13-14 years) and grade 5-6 (10-11 years) for US and UK populations respectively.²⁰ A mind map is a simple, visual method of providing information in a one-page 'snap-shot' representation that promotes critical thinking skills and enhances memory recall by encouraging individuals to think in their own **radial** manner.^{21,22} Incorporating pictures, images and colors has been shown to facilitate the retention of information and may also have a positive effect of **attracting those who prefer a visual learning style**.²³ A number of studies in the literature compared different methods of delivering information, such as patient leaflets, mind map or audio-visual slides, and evaluated the effectiveness of each method by assessing patient retention of treatment information.²⁴⁻²⁹ Thickett and Newton (2006) evaluated short-term and long-term recall of orthodontic patients, and concluded that the use of a mind map demonstrated a superior outcome compared to information leaflets.²⁹ A mind map may be more effective in enhancing recall than other methods of presentation, however it may depend on the nature of the mind map. **A mind map designed by the individual themselves would be anticipated to enhance cognitive engagement with the task. A systematic review and meta-analysis of 55 studies**

across 5818 participants found that mind maps resulted in greater knowledge retention in comparison to more traditional methods of information presentation, and that the effect was increased if the participants were engaged in the development of the map.³⁰ This study will seek to compare the benefits of a pre-prepared mind map with a mind map produced by the patient themselves.

Objectives and hypothesis

The aim of this trial was to determine the most effective way of communicating and delivering orthodontic information to patients and parents in order to maximize their short- and long-term retention of information. This study was designed to compare the efficacy of three methods of delivering information (audio-visual presentation supported by one of three written information: leaflets, generic pre-prepared mind map, or custom-made mind map by a participant). The null hypothesis was that the three different methods of providing information did not make any difference to the recall of information of patients and their parents in the short- or long-term.

Materials and methods

Trial design and any changes after trial commencement

This study was a single centered, prospective, randomized controlled trial. Ethical approval was obtained from the London Bridge Research Ethics Committee (Reference 17/LO/0422). The Committee approved the trial design including randomization and blinding processes, and no changes were made to the trial after its commencement.

Participants, eligibility criteria, and setting

This study was conducted in the orthodontic department at the Royal Bournemouth Hospital, United Kingdom. All patients and parents who attended the Workshop appointment before commencement of orthodontic treatment were recruited in the study. Patients who were 10 years of age or above were eligible for inclusion and all parents whose child agreed to join the study were included. The criteria for exclusion comprised patients/ parents who

lacked capacity to consent, patients with **craniofacial abnormalities** or previous orthodontic experience, and patients/ parents who did not speak English.

The invitation letter and patient information sheet were posted to patients along with their Workshop appointment. More than 24 hours was given for the patients to decide to participate in the study. Before the Workshop began, a PowerPoint presentation regarding the research was given by the researcher, and the patients and parents were given time to ask any questions. When patients agreed to join the study, consent was obtained from the patients and parents. Participants were recruited between May 2017 and December 2017.

Interventions

The routine Workshop appointment involved one of three Dental Care Professionals (DCPs) who provided forty-five minutes audio-visual presentation on orthodontic information followed by the British Orthodontic Society (BOS) leaflets. Several studies have reported that these leaflets are relatively easy to read and written in the standard that 70-80% of the UK population would be able to understand.^{20,31} Therefore, the standard Workshop management was chosen as the control group.

The second group was given the same audio-visual information as the control group except that the written information was given as a mind map. The mind map was prepared using Microsoft PowerPoint and printed as a color laminated A4 (**210 x 297 mm**) sheet (Figure 1). The mind map information was clustered into eight main categories, and emojis and colors were incorporated to draw attention for young patients and facilitate the recall of information. The information on the mind map was checked and approved by two consultant orthodontists. The mind map was also shown to a group of patients to obtain a layman's opinion. Positive feedback, including easy reading and understanding, were obtained.

The third group received the same audio-visual information as the other groups, however they were asked to draw their own mind map using orthodontic information which was important to them. A blank A4 (**210 x 297 mm**) paper and colored pens were provided to

draw the mind map. Guidance on how to draw a mind map was given to the group without providing additional orthodontic information.

When designing the study, the researcher had a meeting with the three DCPs and went through the PowerPoint slides to structure the presentation so that full, accurate and consistent oral health advice was given each time to enable participants to achieve the maximum score.

A research questionnaire (appendix 1) was designed to assess the short- and long-term recall of participants. The questionnaire comprised thirteen questions with a maximum score of 30. It was designed as a closed-ended format to allow for greater uniformity of responses. An independent nurse, not involved in the research, handed out the T0 questionnaire to patients and parents before the Workshop to determine baseline knowledge. Thirty minutes after administration of the audio-visual presentation and written information, the T1 questionnaires were given to assess the short-term recall of information. The participants were monitored during this process to ensure that answers were not affected by any external influence. The same questionnaire (T2) was repeated at the beginning of their follow up appointment 6 weeks later without repetition of information.

Outcomes (primary and secondary)

The primary outcome measure was the knowledge scores of participants, 30 minutes after administration of the information to assess short-term retention, and without repetition of the information 6 weeks later to assess long-term retention. These knowledge scores were compared to the baseline to assess the intervention effect. Demographic information and other participant-related factors were recorded to assess whether there were any variables that might affect the retention of orthodontic information.

Sample size calculation

The sample size calculation for this study was based on one-way ANOVA for comparing mean difference (before and after the workshop) in the knowledge scores between three groups. A study with an effect size of 0.4, 80% power required a total sample of 66 (22 per

group) to test the difference at 5% level of significance using two tailed test. Anticipating a drop-out rate of 30%, a total sample of 93 (31 per group) was considered for this study. The analysis was based on an Intention-to-Treat approach.

Randomization (random number generation, allocation concealment, implementation)

Patients were allocated in a ratio of 1:1:1 to the intervention groups based on the random numbers generated in a standardized way using a computer program. Block randomisation was designed with blocks of 3 (each block contained all three interventions in a random order) to allow a random allocation of the patients and to ensure equal numbers in comparison groups throughout the research. This table was produced by a third party at Bournemouth University Local Research Department.

A unique identifier code was provided to each patient to blind the study. The code and information of a proposed intervention were enclosed in the sealed opaque envelopes that were prepared by a third party at the Local Research Department. The envelopes were double protected with a sticker and sequentially numbered.

These envelopes were assessed just before the Workshop to ensure the envelope seal was not broken and were handed out in the correct order by an individual nurse who was not involved in the research. The nurse accessed the envelopes with the patients and provided written information as recorded in the envelopes.

Blinding

The researcher was blinded from the study by involving the nurse who did not take part in the study. Information on the study groups was also blinded from the statistician to prevent systematic distortion of the data analysis and results. It was not possible to blind the participants since they knew what written information was provided to them.

Statistical analysis

Descriptive statistics such as mean, standard deviation, median, minimum and maximum were used to summarize the knowledge scores for various demographic variables across groups. Percentages were used to summarize the study sample characteristics. The

distribution of knowledge scores was assessed using histogram, box plot and Shapiro Wilk's test. As the knowledge scores followed normal distribution, parametric analyses were carried out to assess the influence of various factors such as time, age, status, group (intervention) and ethnicity on the knowledge scores. The missing data were handled by using random effects model, as this model includes all the available observations in the analysis. If any of the interaction effects were not significant in the initial model, they were removed from the final model. Hence, the final model included all the main effects and significant interaction effects. If the interaction effect was significant in the final model, then further analyses were carried out to find out which combination of interaction effects were significant.

Results

Participant flow

A total of 124 patients were screened and 31 were excluded from the study either due to selection criteria or patients' refusal to take part (Figure 2a). Five patients were subsequently lost during the course of the study. A total of 89 parents participated in the study and 12 parents were lost during the course of the study (Figure 2b).

Baseline data

Demographic characteristics of the participants are shown in Table 1. The mean age of the patients and the parents were 13.2 (± 1.8) and 45.5 (± 9.1) years respectively. There was no significant difference between the three groups with respect to age ($p > 0.05$). The result showed that while the majority of parents attending with the patients were mothers, there was no significant difference observed in the gender distributions within the three groups for both patients and parents ($p > 0.05$ for both patients and parents). Table 2 summarizes the knowledge scores for various demographic variables across groups.

Numbers analyzed for each outcome, estimation and precision, subgroup analysis

As the percentage of missing observations was high (5.91%) across various time points, random effects models were used to assess the influence of various factors on the knowledge scores. The initial model included the main effects of time, status (patient or parent), groups (workshop, generic mind map, participant's customized mind map), ethnicity

(White British or others), age and the interaction effects of time vs group, time vs gender, Time vs status and Time vs ethnicity. Statistical significance was assumed at 5% level.

As the interaction effects namely Time vs Group ($p=0.19$), Time vs Gender ($p=0.11$) and Time vs Ethnicity ($p=0.56$) were not statistically significant in the initial model, these effects were removed. Hence the final analysis model included the main effects of time, status, group, ethnicity and age along with the interaction of Time vs Status. The results are summarized in Table 3. The knowledge scores increased significantly from baseline to time points 1 and 2. The knowledge scores for parents were significantly higher ($p=0.002$) than the patients. The significance between groups indicates that the interventions had significant influence on the knowledge scores. The leaflet and mind map groups did not differ significantly. However, the knowledge scores for participants in the mind map groups were significantly higher ($p=0.025$) than the knowledge scores of participants who were in the leaflet group **for all cohorts**. The difference was not statistically significant between the two mind map groups. The knowledge score did not differ between ethnic groups. The interaction between time and status were statistically significant ($p=0.0002$), hence further comparisons were carried out to find out which combinations were statistically significant.

The knowledge score of patients at baseline is significantly ($p<0.0001$) lower than at time 1 and time 2 indicating that the intervention had increased their oral health knowledge and similar results were observed for parents. At time 1 and time 2, the knowledge scores did not differ significantly between patients and parents ($p>0.05$). The correlation between patient and parent knowledge scores were significant ($p<0.0001$) at all three time points. 100% of the parents answered **in the T2 questionnaire** that they shared information obtained with their child suggesting that the knowledge of the parents affected the knowledge of their children. The rate of forgetting information was less for parents compared to patients.

Discussion

Main findings in the context of the existing evidence, interpretation

Provision of an audio-visual presentation and one of three written information methods is an effective way of producing significant improvement in short- and long-term recall of information in patients and parents. In our study, the null hypothesis was rejected since the administration of the mind maps was demonstrated to improve the recall of information in both patients and parents compared to the leaflets. A similar result was observed in previous research by Thickett and Newton (2006) where the use of a mind map demonstrated a superior outcome compared to BOS leaflets.²⁹ The UK study by Aljabaa et al. (2016) found no statistical significance between the use of a mind map and leaflets in terms of adherence to oral hygiene instructions.²⁴ However, their mind map did not conform to a recognized concept and was not included in the publication for viewing. The current literature review did not show any evidence of past research that assessed the effectiveness of using a mind map produced by orthodontic patients on recall of information.

This research demonstrates the importance of parental involvement in provision of medical information. Parents comprehend and retain information better, and share this with their children thereby improving the patients' recall of information. Regardless of the type of written information, recall of patients and parents degraded from short- to long-term in all groups, a similar finding to previous research by Thickett and Newton (2006).²⁹ It is, therefore, suggested that information be repeated at follow-up appointments.

Patients and parents in all groups of this study reported that written information given was easy to read and comprehend. However, their perception on readability and comprehension of information was not reflected on their knowledge score. When readability of written information reaches a certain level, it may not be a significant factor that affects recall of information by patients and parents. This is supported by the US study of Kang et al. (2009) that demonstrated the use of information leaflets with enhanced readability did not improve recall or comprehension of patients and parents.²⁶

Limitations

The participants **of the study** might pay more attention to the audio-visual presentation and written information in order to obtain a higher score **during the research**. In addition, the T0 questionnaire was given to them before the Workshop to assess their baseline knowledge. It is possible that some participants memorized the questions and selectively learnt the information during the interventions leading to increased short-term knowledge score. The long-term knowledge score was high after 6 weeks, however, was less compared to the short-term knowledge score. This can be due to decay of knowledge or selective learning of the information. The positive effect with the intervention of the study may be overstated.

The BOS leaflets on fixed appliances recommend tooth brushing 'twice daily'. This is a different tooth brushing regimen from **our** department. Therefore, the researcher crossed it out and wrote in 'three times daily' instead. As a consequence, this information might stand out and helped the participants in the leaflet group to retain this particular knowledge.

Generalizability

This study was conducted in a single secondary care setting funded by the National Health Service (NHS) and this may limit its clinical application to other care settings. Patients accepted for hospital treatment generally have more severe malocclusions with a higher treatment need compared to primary care settings, and their behavior and motivation towards treatment may be greater. Treatment is free of charge and responsibility or behavior patterns of patients and parents could be different from ones who pay for treatment. This limitation can be overcome by conducting a multi-centered study.

Not all hospitals or orthodontic practices **have facilities** to provide an audio-visual presentation. Conducting further research on the effectiveness of combining verbal communication with one of the three written information methods in a multi-centered setting may provide more meaningful evidence.

Conclusion

All three methods of delivering information significantly improved the short- and long-term recall of information given. There was a small but significant improvement in the retention of information using the mind maps compared to the leaflets. The generic mind map is equally as effective as the individuals custom-made one. Therefore, provision of a pre-prepared mind map as supplementary written information is recommended, as it is less labor-intensive, potentially cheaper and more consistent in information delivered. Since information recall degraded from short- to long-term in all groups, it is suggested that information be repeated at follow-up appointments.

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Figure Captions

Fig 1. The pre-prepared mind map

Fig 2a. CONSORT flow diagram (patients)

Fig 2b. CONSORT flow diagram (parents)